

Constraining X-ray-Induced Photoevaporation of Protoplanetary Disks Orbiting Low-Mass Stars

Kristina M. Punzi¹, Joel H. Kastner¹, David Rodriguez², David A. Principe^{3,4}, Laura Vican⁵

¹Laboratory for Multiwavelength Astrophysics, Rochester Institute of Technology

²Universidad de Chile

³Núcleo de Astronomía de la Facultad de Ingeniería, Universidad Diego Portales

⁴Millennium Nucleus Protoplanetary Disks

⁵University of California, Los Angeles

Abstract. Low-mass, pre-main sequence stars possess intense high-energy radiation fields as a result of their strong stellar magnetic activity. This stellar UV and X-ray radiation may have a profound impact on the lifetimes of protoplanetary disks. We aim to constrain the X-ray-induced photoevaporation rates of protoplanetary disks orbiting low-mass stars by analyzing serendipitous XMM-Newton and Chandra X-ray observations of candidate nearby ($D < 100$ pc), young (age < 100 Myr) M stars identified in the GALEX Nearby Young-Star Survey (GALNYSS).

Keywords. stars: low-mass, pre-main sequence; techniques: imaging spectroscopy; X-rays: stars

1. Introduction

Low-mass (M-type) stars represent some of the best targets for the discovery of potentially habitable exoplanets due to their low luminosities and the location of their habitable zones. Presently, only a small number of planets have been detected around M stars, with terrestrial planets being common and giant planets being rare, although these results may be affected by a selection bias (e.g., Mulders et al. 2015, Howard et al. 2012). This trend may be a consequence of the intense high-energy radiation fields of low-mass, pre-main sequence stars. A great deal of mass in protoplanetary disks is lost from the surface of the disk due to heating (photoevaporation) from high-energy radiation from the central star. The X-rays from young stars drive disk dissipation and chemistry, influencing the timescale and conditions for exoplanet formation. According to Owen et al. (2012), stellar X-ray luminosity alone sets the photoevaporation rate. However, Gorti et al. (2015) demonstrate that X-ray spectral hardness is also important. Hence, it is necessary to fully characterize the X-ray radiation fields incident on protoplanetary disks.

2. Serendipitously Detected X-ray Counterparts

To constrain the X-ray-induced photoevaporation rates of protoplanetary disks orbiting low-mass stars, we can examine stars from the GALEX Nearby Young-Star Survey (GALNYSS; Rodriguez et al. 2013) that have been serendipitously observed by either XMM-Newton or Chandra. GALNYSS combines ultraviolet (GALEX) and near-IR (WISE and 2MASS) photometry with kinematics to identify candidate nearby ($D < 100$ pc), young (age < 100 Myr), low-mass (M-type) stars. This survey has identified > 2000 candidates, with most of the stars having spectral types in the range M3-M4.

The XMM-Newton data for GALNYSS candidates are being reprocessed and analysed using the Scientific Analysis System following standard procedures [†]. Spectra are extracted from the EPIC detectors using circular regions centered on the 2MASS/WISE positions of the objects. Spectral modelling is performed with XSPEC. An example of the extracted spectra and resulting model fit is displayed in Figure 1. Our models consist of X-ray spectra that result from optically thin plasmas in collisional ionization equilibrium (vapec model in XSPEC) [‡]. These emission spectra were combined with photoelectric absorption by using the XSPEC model wabs.

3. Conclusions and Future Work

Our preliminary results demonstrate that serendipitous XMM-Newton observations of GALNYSS stars are capable of producing useful constraints on the stellar X-ray temperature and luminosity and hence, on photoevaporation due to X-ray irradiation. These early results suggest that X-ray photoevaporation may not account for complete disk dispersal at ages ~ 8 -20 Myr. For the entire sample of serendipitously observed GALNYSS stars, we will determine X-ray temperatures and luminosities, the potential correlation between M star L_X and residual disk mass, and the mass dependence of L_X/L_{bol} .

References

- Gorti, U., Hollenbach, D., & Dullemond, C. P., 2015, *ApJ*, 804, 29.
Howard, A. W., Marcy, G. W., Bryson, S. T., et al. 2012, *ApJS*, 201, 15.
Mulders, G. D., Pascucci, I., & Apai, D. 2015, *ApJ*, 798, 112.
Owen, J. E., Clarke, C. J., & Ercolano, B., 2012, *MNRAS*, 422, 1880.
Rodriguez, D. R., Zuckerman, B., Kastner, J. H., et al., 2013, *ApJ*, 744, 101.

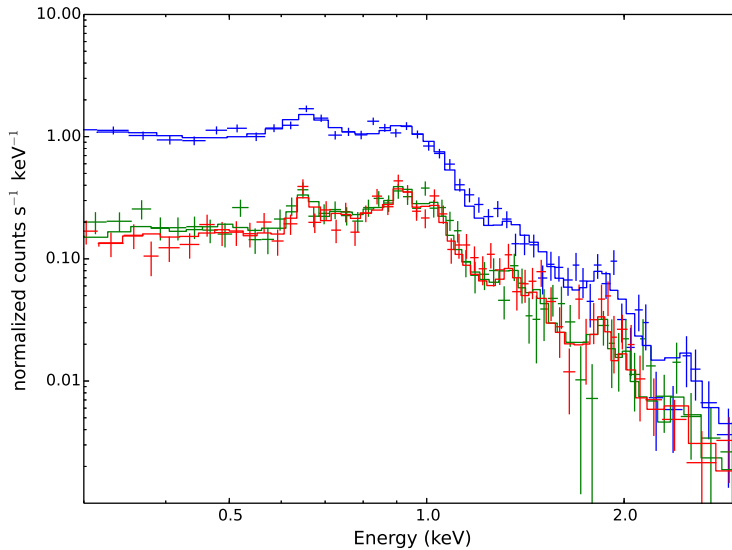


Figure 1. XMM-Newton EPIC extracted spectra (crosses) of J061313.30-274205.6 (spectral type M3, β Pictoris Moving Group candidate – 99.24% likelihood) for pn (blue) and MOS (red and green) detectors. Overplotted are the best-fit models (histograms). Our model predicts plasma temperatures of ~ 3.6 and ~ 12 MK and an X-ray luminosity of 1.2×10^{29} erg s $^{-1}$ at a distance of ~ 25 pc.

[†] See the SAS documentation at <http://xmm.esac.esa.int/sas/current/documentation/threads>.

[‡] See the XSPEC documentation at <https://heasarc.gsfc.nasa.gov/xanadu/xspec/manual/Models.html> for a description of the models.